AN EMISSIVE ANTENNA CORRECTION FOR THE TROPICAL RAINFALL MEASURING MISSION MICROWAVE IMAGER (TMI)

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ABSTRACT

The 17-year time series of TMI precipitation measurements is an important climate record. Since the upcoming TMI 1B11 version-8 will be the legacy brightness temperature (Tb) data product, it is crucial to have a transparent counts-to-Tb algorithm based upon rigorous physical principles. This Tb product will be used to establish the inter-satellite radiometric calibration between TMI/GMI that is the basis for extending the TRMM precipitation measurements into the GMI era. However, the Tb calibration of the TMI is compromised because of an issue with the reflector antenna, and this paper deals with an improved correction developed by CFRSL.

INTRODUCTION

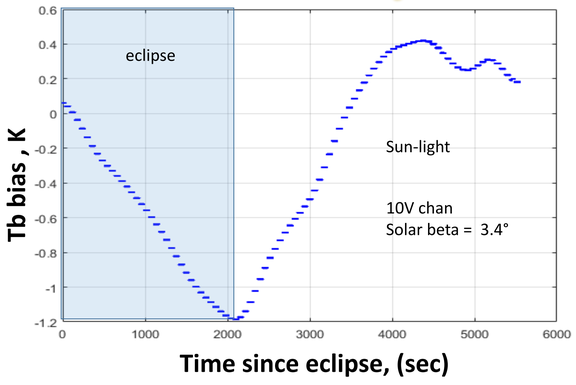
Since launch, TMI's Tbs has been degraded by a slightly emissive main reflector antenna

$$Tb_{measured} = (1-\varepsilon)Tb_{scene} + \varepsilon T_{physical}$$

ε is the reflector emissivity (~ 0.03)
Tb_{scene} is the desired surface brightness temp
T_{phy} is the reflector temperature (not measured)

This resulted in a time-varying radiometric calibration error of ± 0.75 K over one orbit and ± 1.5 K over seasons for all channels (freq/pol)

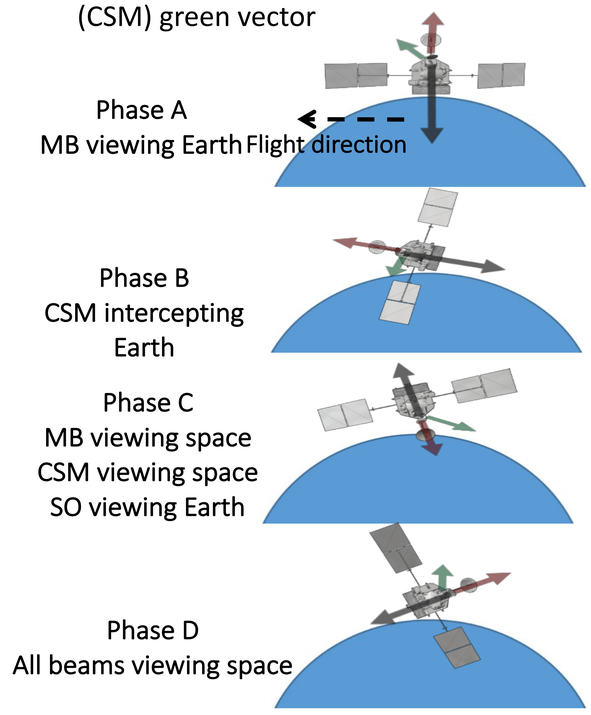
1DTb Bias 1B11 V-7, Yaw0



- In 2009, this issue was identified & an ad-hoc correction applied in the 1B11 V-7
- Tb Bias = f(solar beta ang, time since eclipse, yaw)

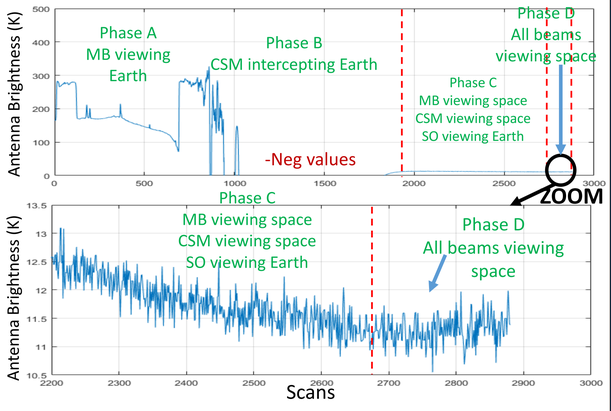
Deep Space Calibration (DSC) Maneuvers

- During 2015, an improved DSC maneuver was performed
  - TRMM yaw attitude = 90°and roll attitude completed 360°rotation during one orbit
  - Thus causing TMI antenna to view "cold space" brightness temperature = 2.73 Kelvin
  - TMI antenna system comprises 3 beams:
    - Main Beam (MB) black vector, Spill-Over (SO) red vector, and Cold Sky Mirror (CSM) green vector



- The maneuver resulted in all beams viewing space simultaneously

TRMM Deep Space Maneuver 2015

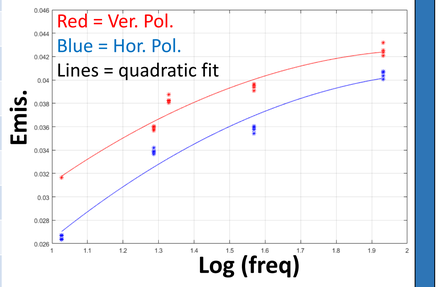


Emissivity Derivation

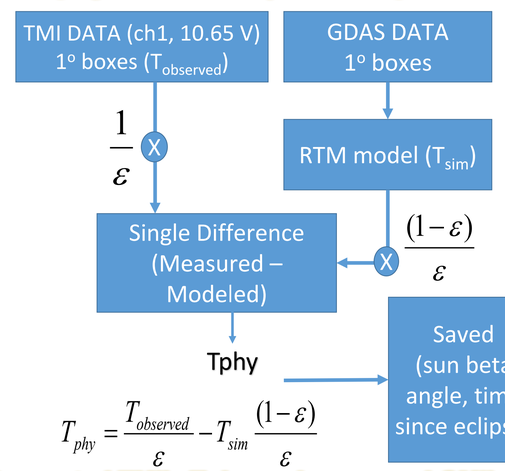
- GMI's measured reflector physical temperature, at the same sun beta angle and time since eclipse, was used to derive channel emissivities

Channel	CFRSL e
10.65 V	0.03163
10.65 H	0.02654
19.35 V	0.03586
19.35 H	0.03390
21.30 V	0.03832
37.00 V	0.03940
37.00 H	0.03580
85.50 V	0.04253
85.50 H	0.04045

$$\varepsilon_i = \frac{< T_A > -2.73}{(1-\eta_i) * (T_{phy} - 2.73)}$$



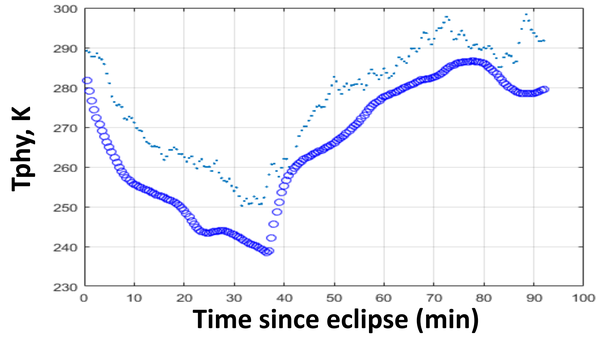
Tphy derivation (normal operation)



$$T_{phy} = \frac{T_{observed}}{\varepsilon} - T_{sim}\frac{(1-\varepsilon)}{\varepsilon}$$

Computed TMI's Tphy and measured GMI's Tphy

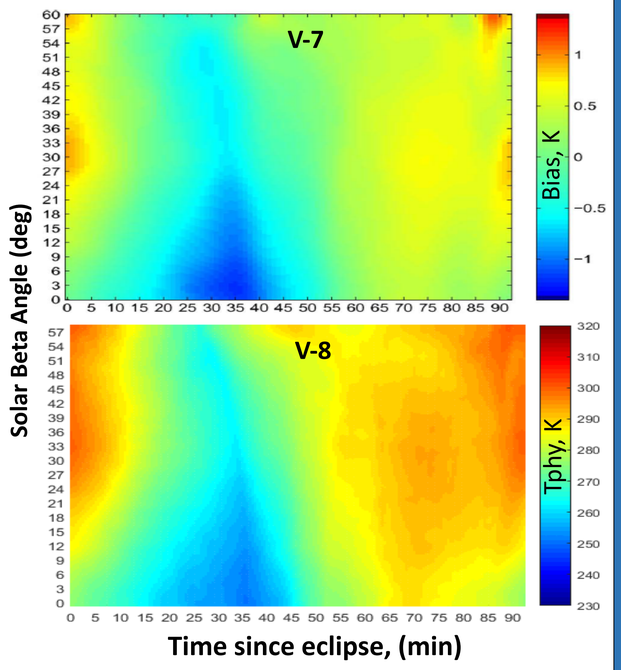
- TMI and GMI have similar spinning reflector antennas, but they operate in different orbits
- However, at an identical solar beta angle, they experience comparable solar heating environment
  - Heating in day light and cooling in eclipse time



Results

- Look-up results for both V-7 & V-8
  - 2D bias table for V-7
  - 2D physical temperature for V-8
    - V-8 includes the hot load corrections

2D Tb Bias 1B11 V-7 & V-8, Yaw0



2D Tb Bias 1B11 V-7 & V-8, Yaw180